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Book Review: *Geometry from Africa: Mathematical and Educational Explorations* by Paulus Gerdes

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Geometry from Africa: Mathematical and Educational Explorations. Paulus Gerdes. Washington, DC: The Mathematical Association of America, 1999.

Books by Paulus Gerdes fill a complete shelf of my bookcase—and I don't have all of them. A professor of mathematics and former rector of the Pedagogical University in Mozambique, he writes in Portuguese, French, English, and German, and has published over a hundred journal articles and books, several of which have won awards. In this 1999 MAA publication, he has gathered into one compendium many of the ideas from his previous works. The volume is beautifully illustrated by hundreds of his own masterful computer graphics, as well as by photographs of the art objects discussed in the text.

In his insightful Foreword, Arthur B. Powell (Rutgers University) writes: "Through [Paulus Gerdes], we learn of the diversity, richness, and pleasure of mathematical ideas found in Sub-Saharan Africa. From a careful reading and working through this delightful book, one will find a fresh approach to mathematical inquiry as well as encounter a subtle challenge to Eurocentric discourses concerning the when, where, who, and why of mathematics" (p. v).

Gerdes is a major contributor to the emerging field of ethnomathematics. He and his research team have been investigating the geometrical ideas encoded in African cultural products, and have brought to light the mathematical concepts "hidden" or "frozen" in these artifacts and ornaments.

The book is divided into four sections, each concluding with a voluminous bibliography. The first section, "On geometric ideas in Africa south of the Sahara," opens with a discussion and reproductions of ancient rock paintings and petroglyphs, pots and gravegoods from various parts of the continent, some dating back several millennia. Gerdes invites the reader to analyze the symmetries in thousand-year-old textiles from

Mali, interwoven in a variety of patterns of white and indigo-dyed strands. Many pages are devoted to the stunning productions of the Kuba artists of Congo/Zaire, all adorned with geometric designs and repeated patterns—objects of copper and iron, woven baskets and mats, carved wooden cups and drums, beaded hats, pottery, and much more. Photographs and carefully drawn computer renderings encourage the reader to apply the concepts of transformational geometry to the patterns.

The kente cloth of the Ashanti (Asante) of Ghana has become popular in the United States in its many derivative forms. Less familiar are the repeated patterns stamped on adinkra cloth and the designs on brass weights used to weigh gold dust in past centuries.

Included in this section are examples of various arts in many areas of the continent—patterns in body painting and hair styles, mural decoration, basket weaving, leather work, calabash engraving, wood carving, and decorative metal work. Gerdes concludes with the statement: "May the examples given in this chapter convey to the reader an idea for how women and men all over Africa south of the Sahara, in diverse historical and cultural contexts, traditionally have been geometrizing" (p. 50).

In chapter two, "From African designs to discovering the Pythagorean Theorem," Gerdes demonstrates how "African ornaments and artifacts may be used to create an attractive educational context for the discovery of the Pythagorean Theorem and for finding proofs of it" (p. 55). He begins with a description of button-making in southern Mozambique, using two strips of a palm leaf. With some abstraction and manipulation of the process, one arrives at a diagram showing that the sum of the areas of the squares on the two legs of a right triangle is equal to the area of the square on the hypotenuse. From this humble example, he extends his exploration to a variety of traditional African designs having four-fold rotational symmetry.

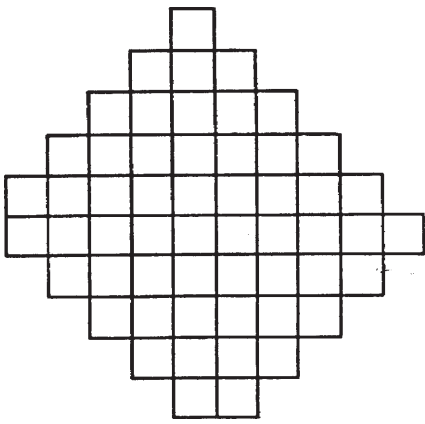


Figure 1
Kuba Network

From several different patterns based on squares, Gerdes derives “an infinity of proofs” of the right-triangle theorem, as well as formulas for the sum of the first $(n - 1)$ natural numbers and the first n odd integers. A different embodiment of squares in a woven mat leads, again, to the theorem, as well as to Latin squares, magic squares, and arithmetic modulo n .

The third section, “Geometrical ideas in crafts and possibilities for their educational exploration,” deals with such topics as symmetry of strip patterns and plane patterns, areas and volumes of various shapes, and, surprisingly, the connections between the geometry underlying a hexagonal basket-weaving technique and that of models of certain carbon molecules. The Nobel prize in chemistry was awarded in 1996 for the discovery of these molecules, named buckminsterfullerenes.

I have a special affection for chapter four, “The ‘sona’ sand drawing tradition and possibilities for its educational use.” Long before I had met Paulus Gerdes and learned about his work, I included in my book *Africa Counts: Number and Pattern in African Cultures* (1973, 1999) a brief description of network patterns of the Kuba and Chokwe (Tchokwe, Jokwe) peoples. Kuba children drew designs in the sand in imitation of adult fishing nets (Fig. 1). The children challenged a visiting Hungarian ethnologist, Emil Torday, to draw each of these figures in one sweep, without lifting his finger or retracing a line segment, something he declared to be an “impossible task.” Yet these children were doing it. The Chokwe of Angola, as well as neighboring peoples, had a tradition of drawing *sona* in the sand to accompany stories, proverbs, and riddles, a

way of transmitting knowledge to the younger generation (Fig. 2).

Soon after the publication of *Africa Counts*, I collaborated with several middle and secondary classes to adapt these networks, an aspect of graph theory, for classroom use (Zaslavsky 1981, 1991, 1996, in press). Students found it difficult to believe that these “fun” activities were really math! As one mathematically advanced ninth-grader commented, with his algebra and geometry classes in mind, “They are nice for recreation, but they are not *real* math.” On the other hand, an African-American sixth-grade student wrote: “I feel very strongly and am in deep thrust [sic] with my black people, and the math has made me feel better.”

Gerdes opens the chapter with information about the Chokwe and neighboring peoples, and the role of *sona* in their culture. Mathematically, he goes far beyond the content of the lessons I had prepared. Among the concepts he applies to these *sona* are symmetry, monolinearity, chain rules for joining several *sona*, arithmetic progressions, and various numerical patterns. From his analysis of these *sona*, Gerdes derived a new class of geometric activities that he named Lunda-designs and Lunda-patterns, from the Lunda region inhabited by the Chokwe. Applying the symmetries of certain *sona*, one can derive sets of fascinat-

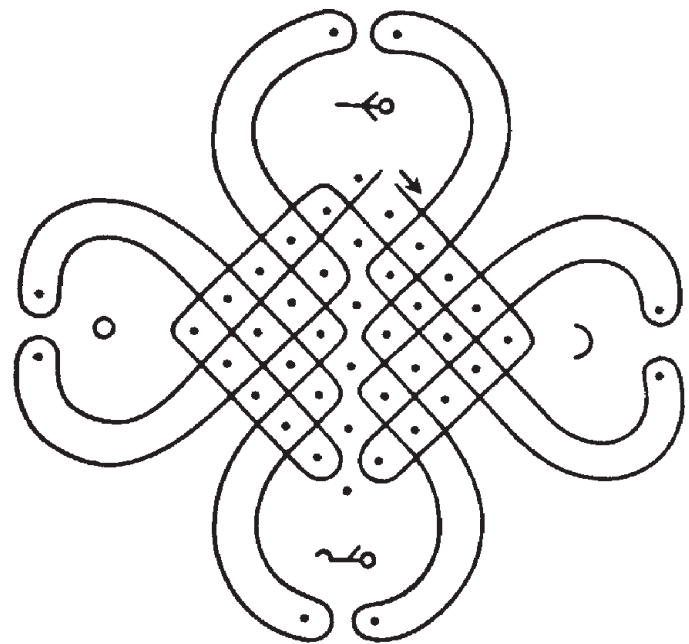


Figure 2
Chokwe Network

ing geometric designs, leading to the building of fractals, matrix addition, polyhedra designs, and polyomino activities appropriate for children (and adults) of any age.

In his Foreword, Arthur Powell quotes Gerdes on his research methodology:

We looked to the geometrical forms and patterns of traditional objects...and posed the question: why do these material products possess the form they have? In order to answer this question, we learned the usual production techniques and tried to vary the forms. It came out that the form of these objects is almost never arbitrary, but generally represents many practical advantages and is, quite a lot of times, the only possible or optimal solution of a production problem...Applying this method, we discovered quite a lot of 'hidden' or 'frozen' mathematics (p.vii).

Mathematicians, students of mathematics, anthropologists, and the lay public can learn a great deal of mathematics from this book, while gaining an appreciation of the beauty and intricacies of African art and culture.

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Qualitative Quantities

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Numbers, we thought, were empty holes
for things in multiples and rows:
spaces for lineal progressions,
holders for nominal abstractions—
empty, vacuous, estranged
from colors and emotive names.

But now we find that numbers hold
associations—fragrant, bold—
innoculants against the cold.

An oily seven, rounded five
are bouncy, quirky, half alive.
Eight is rough and ten is smooth,
and nine an incipient burst balloon.
Numbers with personality
are the ultimate irrationality
in a field renowned for its perfection:
math as queen, as Number One
in platonic space, ad infinitum.

Only humans would make a religion
from wholes, square roots, and fractions,
and greet with unfathomable horror
the realization of the zero;
and find in numerology
a qualitative alchemy—
to work with abacus and crucifix
in efforts hardly apolitical
to fix the names of enemies to 666.

There is more between heaven and earth, Horatio,
than square and cube and ratio;
between stone tool and complex widget
more than the abstract humble digit.
Embodying secret codes of hope and fate,
justice, transcendental love and hate,
like Rorschachs, numbers are used to carry
sums of self—the qualitative territory
of the perfect imaginary.